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THE LUNAR RILLS

by

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Description

The lunar rills are clefts or furrows, found everywhere on the moon but much less frequently on the large dark plains, called the maria. A little more than a thousand have so far been mapped, but there are probably several thousand at or below the limit of visibility. However, the scarcity of rills in the Ranger VII photographs was surprising. The great majority are linear, infrequently are arcuate and a few are sinuous. Often they follow an uninterrupted course, without regard to obstacles such as craters, mountains, ridges or plains, through which they pass indiscriminately. They vary in length from tens to hundreds of kilometers, in width from a few hundreds of meters to 25 kilometers, and in depth from about 35 to thousands of meters (very rarely).

Discovery and Designation

The German astronomer J. H. Schröter is credited with the discovery of the rills in 1787, and the first one he detected now bears his name, viz. Schröter's Valley. He found the first eleven with a modest telescope of a few inches aperture, between 1787 and 1801. He called them <u>rillen</u>. Designation, with few exceptions, is assigned to a nearby prominent feature, usually a crater, e. g. Ariadaeus Cleft which starts near the crater Ariadaeus.

[redacted]

Classification

The lunar rills may be classified into at least four groups, with possible genetic differences. One category comprises the largest ones that really have more the forms and dimensions of valleys. Nearly all are found in the uplands regions of the moon. Three of the finest examples of this group are (1) the 120 km long Alpine Valley, which cuts through the lunar Alps mountain range that forms part of the border of the largest mare, Mare Imbrium (Sea of Showers). It tapers from 10 km down to 1.5 km in width and is over 1.5 km deep. It has a remarkably flat floor, which in turn is pitted and contains smaller rills on it. (See Plate I, Figure g). (2) The Rheita Valley, in the southern highlands, is about 175 km long, has a maximum width of 25 km and a depth of some thousands of meters. It has several craters on it that have evidently subsided with the valley. (3) The Ariadaeus Cleft (Figure b) is a magnificent example almost centrally located on the visible hemisphere of the moon. It is approximately 225 km long, has a maximum width of 5 km and is about one km deep. Its floor is sometimes flat, sometimes convex and sometimes actually has a central ridge, a feature displayed by many of the valleys. (Fielder, 1961).

A singular characteristic of the valleys is their linearity, where their radii of curvature are practically that of the radius of the moon, i.e. about 1000 km or so. Those that depart from linearity are arcuate with radii of curvature of about 100 km, as in Figure f. The one exception is Schröter's Valley, which is zigzag, with radii of curvature of the order of a kilometer or so. It is classified in another category. The edges or banks of the valleys are often scalloped or serrated along their lengths. (See Figure g).

The second class, the normal rill, is composed of the vast majority of all lunar rills. Characteristically they are linear, occasionally arcuate, narrow, and perhaps relatively deeper than other types, but still shallow compared to width. Their sides are of equal height, as if rent apart, with fairly straight edges. These normal rills often exhibit parallelism, en echelon arrangement and intersection, illustrated in Figures j, h (bottom) and h, respectively. They are largely associated, probably genetically, with the maria, often distributed radially, tangentially or paralleling them on the surrounding uplands. Occasionally a rill may end as a ridge, as in the Bürg rill, in Figure i.

The third class of rills is the rare sinuous rill, first called to attention by W. H. Pickering (1904). He thought that they differed from the normal rills because of several common characteristics. These are: (1) They are wider at one end, tapering usually to invisibility at the other, (2) They are deeper at the wide end, (3) They originate in a crater at the wider, deeper, higher end, (4) Their lengths are composed of arcs of very short radius, (~1 km), giving them a winding or zigzag appearance, most commonly alluded to, in the literature, as "looking like a dried river bed." They are found mostly on the dark, flat-floored large craters, or on the shallow parts of the maria. Their lengths, with few exceptions, are a few tens of kilometers, widths are a few hundreds of meters and depths are around 100 meters, rarely a few hundreds of meters. Figures c and d show two of the largest ones, Schröter's Valley and the Hadley rill, the latter is located at the foot of the magnificent lunar Apennines mountains that are also part of the Mare Imbrium border.

The fourth type of lunar rill is the crater-chain rill. This is a furrow composed almost entirely of aligned, contiguous or overlapping craters. Often the banks are elevated above the surrounding terrain. Frequently, perhaps always, they end in an ordinary rill, and sometimes they continue as a ridge. Two fine examples can be seen in Figures b and e.

Origin

It is generally agreed that the rills mark sites of systems of fractures of the lunar surface. Selenologists disagree on the causes of fracturing, whether due to external or internal sources. Externalists, such as Baldwin (See Cameron, 1964, for references) postulate lunar impacts of asteroids which produced the maria (and most of the craters) and attendant radial, etc. fractures. Supporting evidence is cited in the apparent absence of lateral displacement of the moon's surface. By the impact hypothesis, the different types of rills are fundamentally the same phenomena in different manifestations, depending on local conditions. Valleys are assumed to be subsidence features between two approximately parallel faults, i.e. grabens. However, some authorities propose that the radial ones were formed by scouring from ejecta fragments. Crater-chains are thought to be cases where the fractures tapped local pockets of magma, in which blow-hole type (maar) craters formed in the fissure, a common terrestrial occurrence. Sinuous rills, accordingly, are merely the sites of intersecting systems of fractures.

Internalists, such as Knabakov and Spurr, (see Cameron, 1964 for references) favor the hypothesis that the origin of the maria and attendant faulting resulted from the slow selenological growth of their basins and other tectonic movements. Both factions invoke igneous processes for the filling of the marial basins. The above explanations of the various classes of rills can be held for either theory. However, there is room for dispute regarding the sinuous rills. It can be argued that the normal rills exhibit intersection of systems of faults and they result in the formation of <u>T's</u> and <u>X's</u>, whereas the forms of the sinuous rills are <u>U's</u>, <u>L's</u> or <u>Y's</u>. Nearby normal rills show the former shapes but the sinuous ones do not. The intersecting fault hypothesis ignores two pertinent facts that appear to have bearing on their origin. The sinuous rills frequently are deflected by local topography (see Figure d), in contradistinction to the uninterrupted courses of the ordinary rills. The other observation is the intimate association with a crater at the <u>higher</u>, <u>wider</u> end. This implies a volcanic and erosional origin for the rills (Cameron, 1964). Such an origin is strengthened by analogy to terrestrial channels eroded by ash flows, explosive, extremely mobile, fluidized mixtures of gas and ash at high temperature, in which large boulders are suspended. (Occasionally, lava flows erode channels, too.) Typical of these awesome terrestrial ash flows is the one from Mont Pelée that destroyed St. Pierre, Martinique, in 1902. Further support is obtained from recent lunar observations of gaseous emanations from Schröter's Valley and nearby locations. (Greenacre and Barr, 1963). Ash flow phenomena are treated more fully by Aramaki, Perret and Ross and Smith, see Cameron, 1964 for references. These ash flow channels are sometimes sinuous because the fluidized dust (or lava), like rivers, follows paths of least resistance, such as topographical depressions and less resistant materials. Although lunar conditions of no atmosphere or surface water preclude aqueous erosion as the cause of the sinuous rills, they do not rule out ash flows. On the contrary, lunar conditions actually are more favorable for the propagation of ash flows, than are terrestrial conditions. (O'Keefe and Cameron, 1962). Channel erosion results, mostly from abrasion, when the gas content of the ash flow is lowered, at which time the huge boulders are no longer suspended and then roll along the ground, scraping and digging the surface.

The recent Ranger VII photographs show that the lunar surface is quite smooth, down to the limit of resolution of one foot (30 cm). They also indicate recent volcanism. (O'Keefe, 1964). They do not rule out ash flows as significant lunar phenomena.

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FIGURE CAPTIONS

Plate I

(a) A composite to make an apparent full moon photograph in relief. (Lick, 36"). The locations of figures b to j are outlined in white. The cardinal points at top and right are in the astronautical convention, but the orientation is that as seen in a telescope. The photographs are by permission from the respective observatories parenthesized.
(b) A valley type rill, the Ariadaeus Cleft (left) and a crater-chain type, the Hyginus rill (MacDonald); (c) A sinuous rill or valley, Schröter's Valley (Mount Wilson); (d) A sinuous type, the Hadley rill (Lick, 120"); (e) A crater-chain example, the Stadius rill (Lick, 36"); (f) Arcuate valleys bordering Mare Humorum, the Hippalus rills (Lick, 36"); (g) A valley type, the Alpine Valley (Lick, 120"); (h) Normal rills, Triesnecker rills, showing en echelon arrangement, near the bottom, and intersection, in the middle and upper part (Mount Wilson); (i) Normal rill becoming a ridge (light streak at upper left), the Bürg rill (Mount Wilson); (j) Normal rills and valley types showing parallelism. The large dark, flat-floored crater at right center is Ptolemäus, 150 km diameter (Mount Wilson).